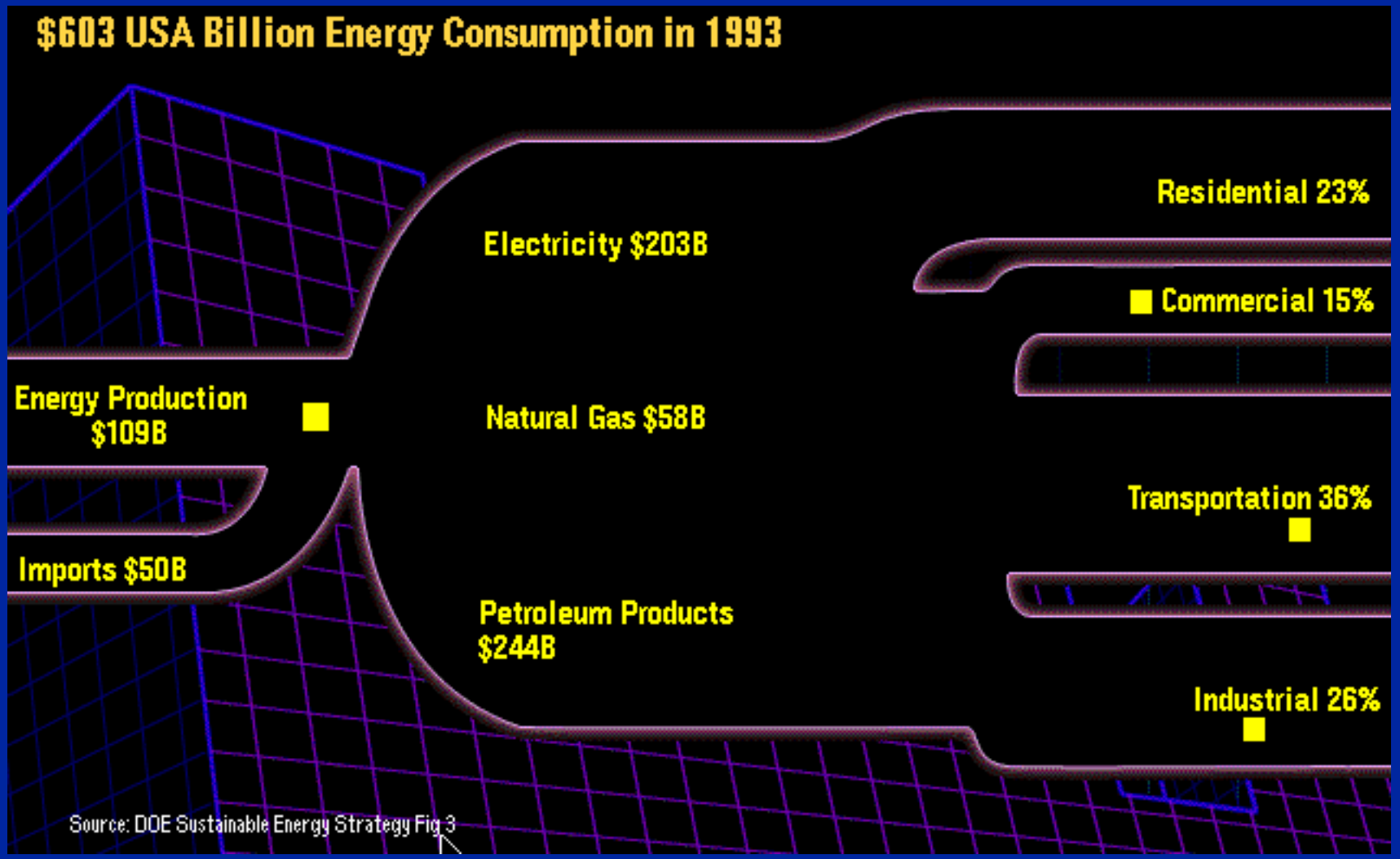
Building Renewable Assets

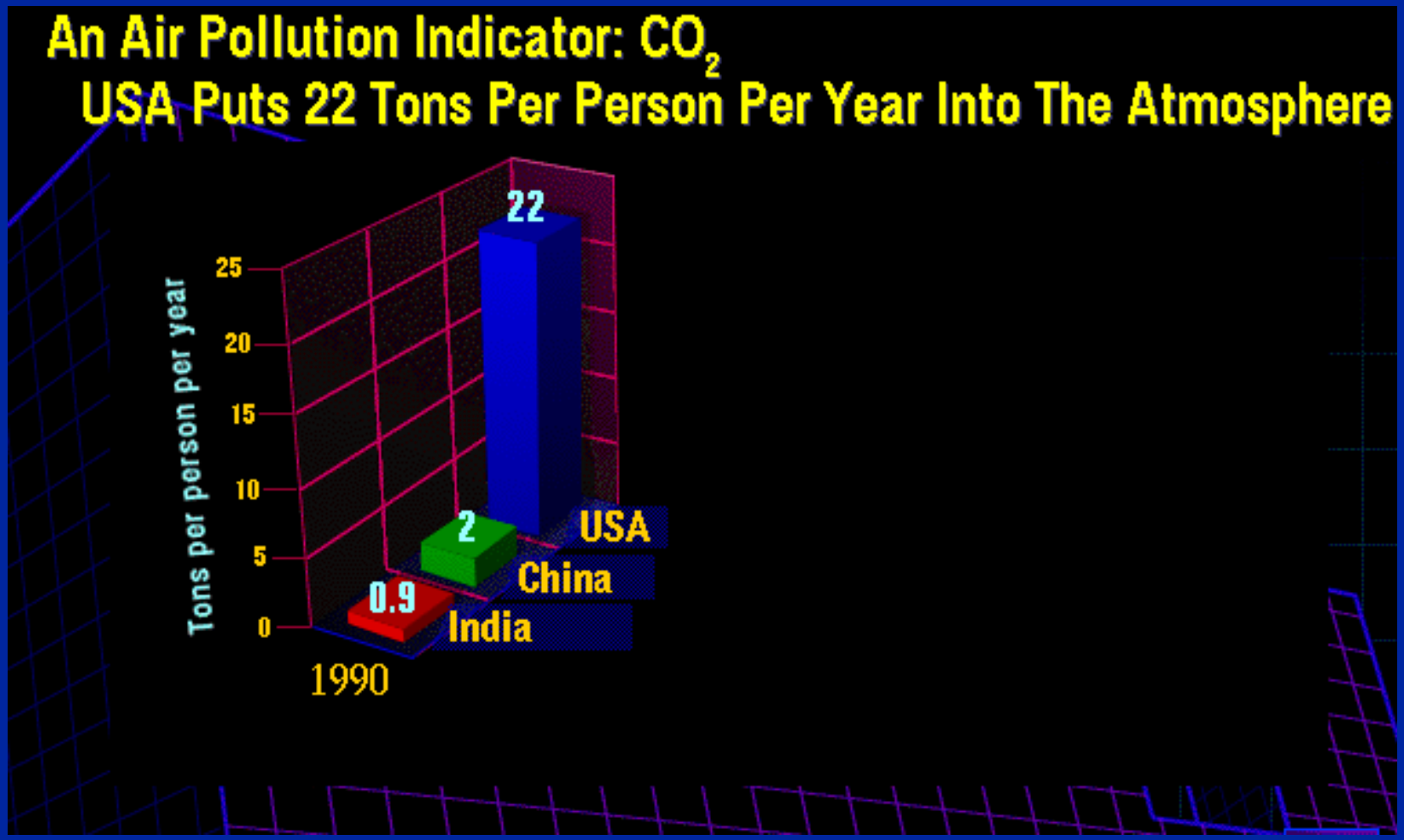
Towards Sustainability

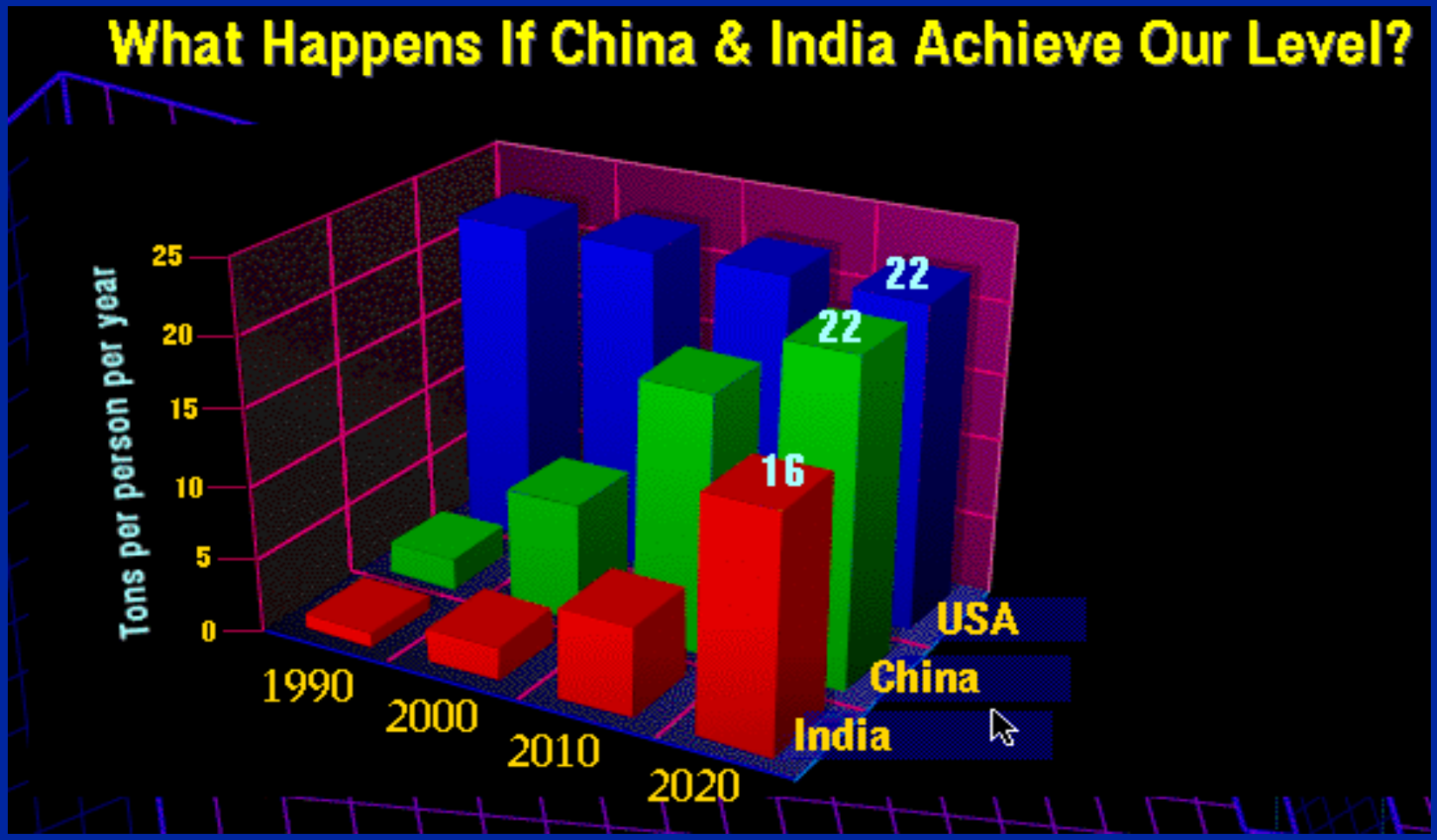
The Intelligent Workplace
The Building as Power Plant

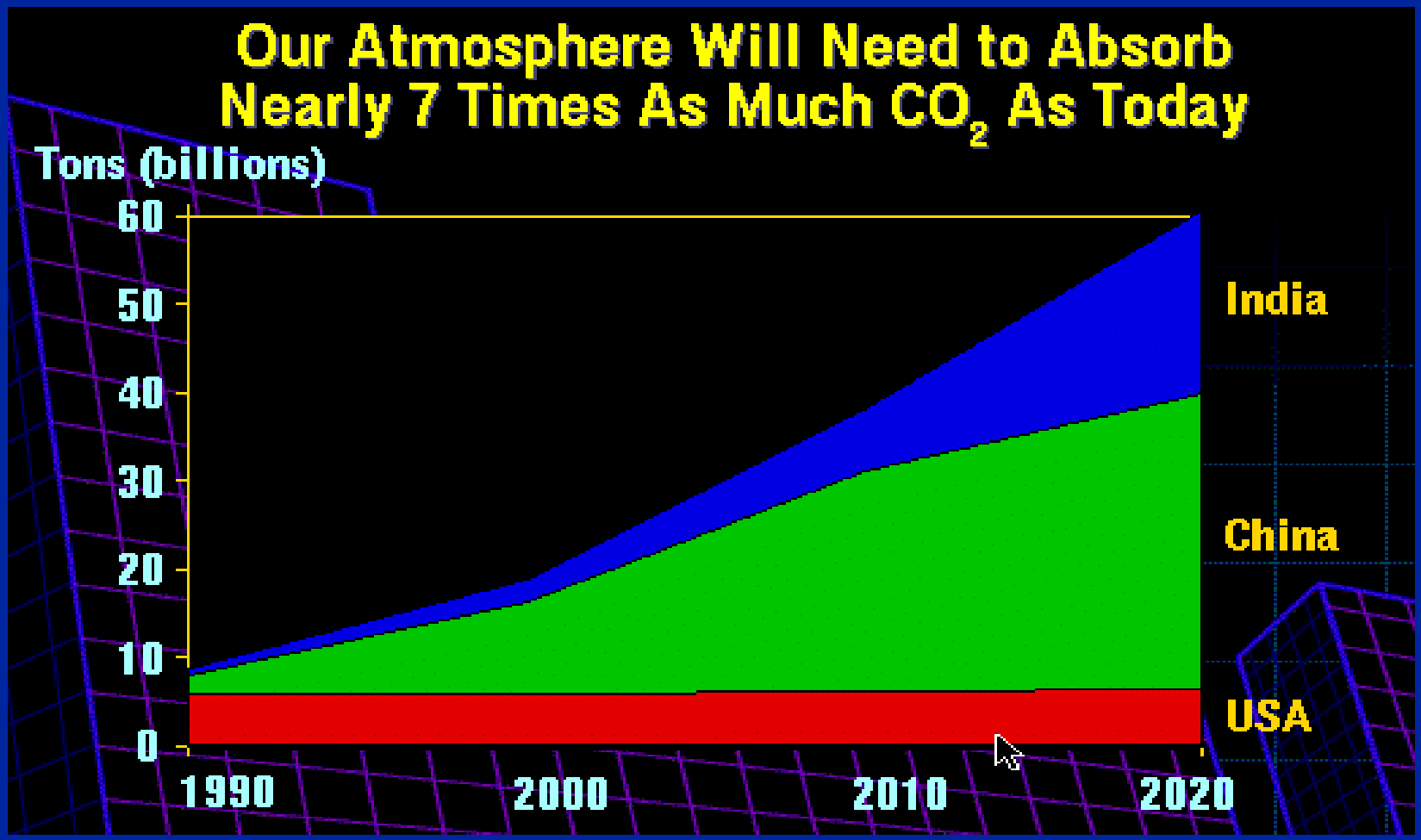
Volker Hartkopf, Prof. Dr. Ing., Director
Center for Building Performance and Diagnostics
School of Architecture,Carnegie Mellon University

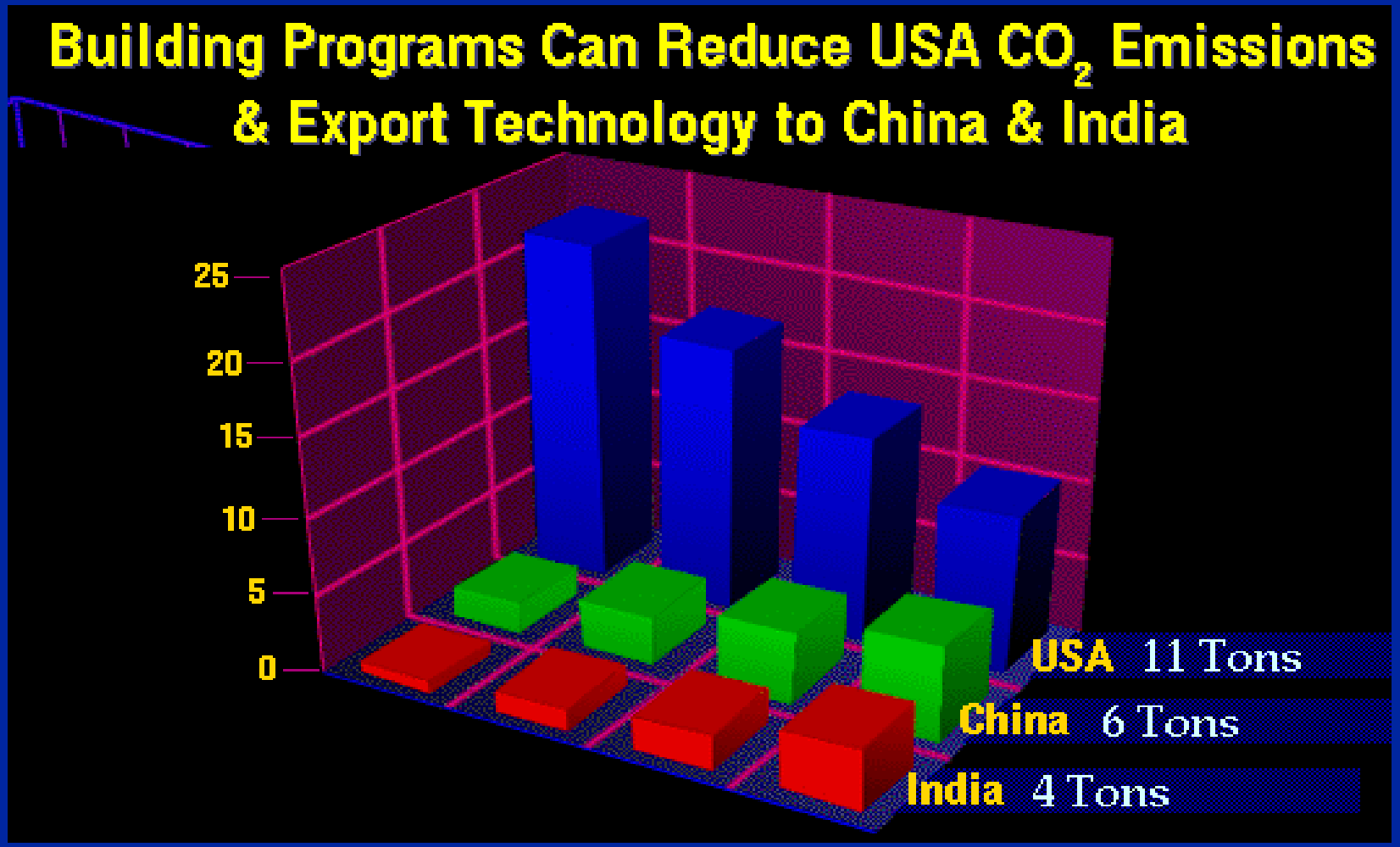
Laboratories for The 21. Century, EPA 2002


$603 USA Billion Energy Consumption in 1993
Energy Production $109B
Imports $50B
Electricity $203B
Natural Gas $58B
Petroleum Products $244B
Residential 23%
Commercial 15%
Transportation 36%
Industrial 26%
Source: DOE Sustainable Energy Strategy Fig 3


An Air Pollution Indicator: CO_2
USA Puts 22 Tons Per Person Per Year Into The Atmosphere
Tons per person per year
25
20
15
10
5
0
22
2
0.9
USA
China
India
1990


What Happens If China & India Achieve Our Level?
Tons per person per year
25
20
15
10
5
0
1990
2000
2010
2020
22
22
16
USA
China
India


Our Atmosphere Will Need to Absorb
Nearly 7 Times As Much CO_2 As Today
Tons (billions)
60
50
40
30
20
10
0
1990
2000
2010
2020
India
China
USA


Building Programs Can Reduce USA CO_2 Emissions
& Export Technology to China & India
25
20
15
10
5
0
USA 11 Tons
China 6 Tons
India 4 Tons

In Search of Collective Competence

The Robert L. Preger

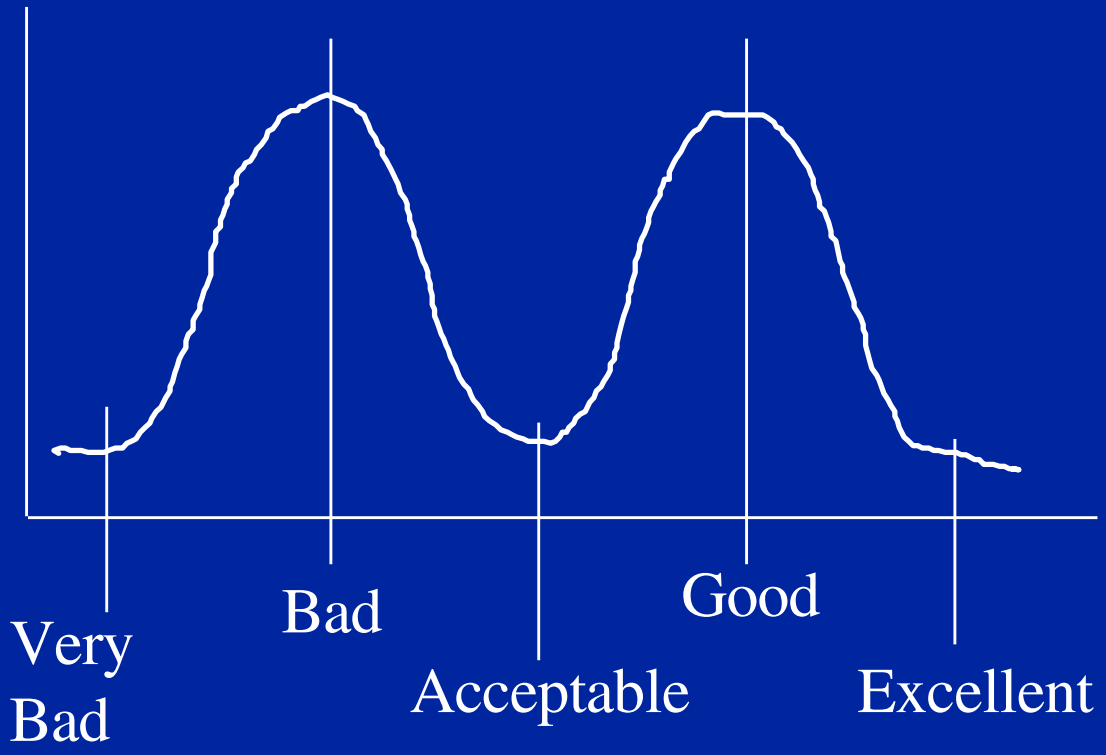
Intelligent Workplace

The Advanced Building Systems Integration Consortium

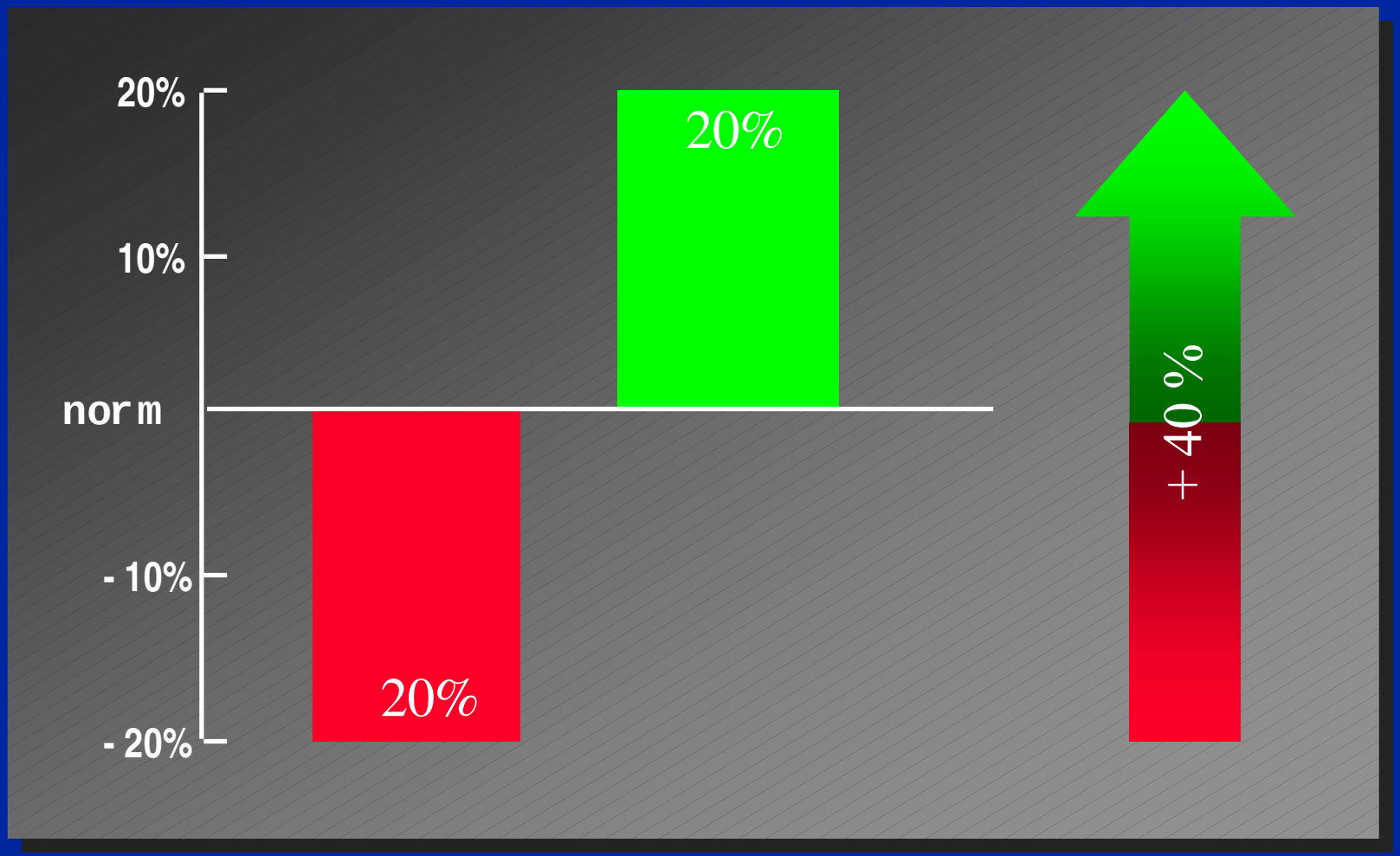
Mission

- Fundamental improvement of the work environment in commercial buildings with a simultaneous reduction of energy consumption and environmental impact
- Goal: Two times FACTOR FOUR :
- Four-fold improvement in quality of life (measured by occupants' satisfaction)
- With a simultaneous four-fold reduction of nonrenewable energy consumption and environmental burden

Improving User Satisfaction



Worker Productivity Improvement



Advanced Building Systems Consortium

- Armstrong World Industries
- AMP Incorporated
- Bricsnet
- BP Solar
- Con Edison
- Electricite de France
- Johnson Controls, Inc.
- LTG Lufttechnische GmbH
- Siemens Energy & Automation, Inc.
- Steelcase, Inc.
- Thyssen Krupp
- Technion
- UTC/Carrier/Otis
- Zumtobel Staff Lighting, Inc.

- National Science Foundation
- US Department of Defense
- US Department of Energy
- US Department of State
- US Environmental Protection Agency
- US General Services Administration

- Dutch Building Ministry
- Public Works and Government Services Canada
- Carnegie Mellon University

The successful interaction of

People
Process
Technology, and
Place

enable the execution of business strategies

(after Kenneth Alvares, VP HR SunMicrosystems during
National Summit on Building Performance, Wahington DC, 1996)

Four Categories of Performance

1 Thermal, visual, acoustic, spatial/ergonomic, and air quality for each occupant

PERSONAL MOTIVATIONAL ENVIRONMENT

2 Organizational flexibility to enable teaming for different group sizes and individual thinking work

ORGANIZATIONAL CHANGE ON DEMAND

Four Categories of Performance, cont.

3 Technological adaptability for rapidly evolving multi media communication and decision support systems for global connectivity

TECHNOLOGICAL CHANGE ON DEMAND

4 Energy and environmental effectiveness to minimize energy investment and environmental degradation during construction, operation, maintenance and physical change to respond to organizational and technological requirements

BUILDING AS RENEWABLE AND SUSTAINABLE ASSET

Four Plug and Play Systems

1 PLUG AND PLAY BUILDING INFRASTRUCTURES

Floor or Ceiling Based “Migrating” HVAC, Lighting, Electrical, Communication, Computation Systems With One-Per-Person Terminal Units & Individual Control

2 PLUG AND PLAY INTERIOR SYSTEMS

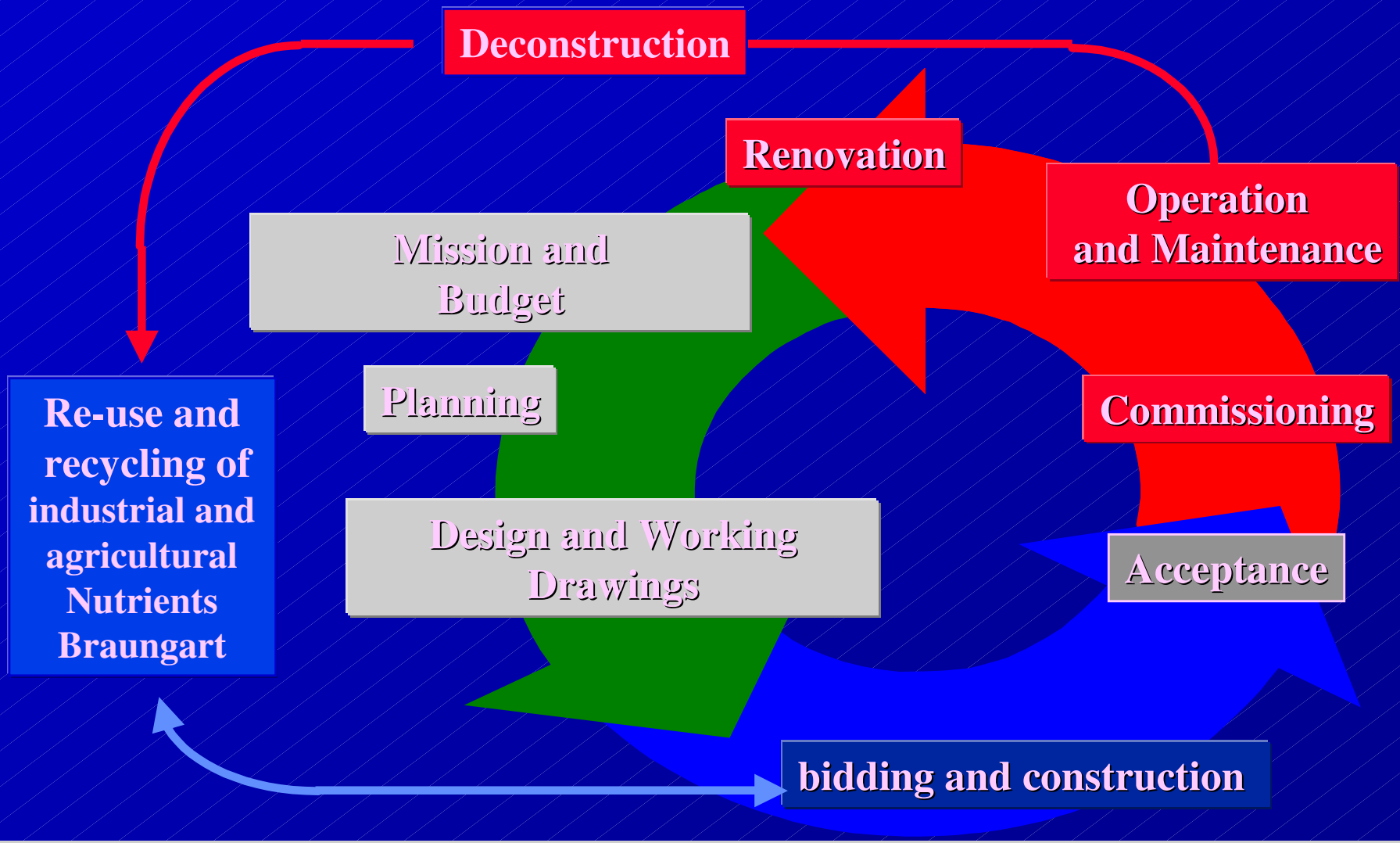
Furniture, Partitions, Walls and Their Interfaces With the Infrastructures

Four Plug and Play Systems, contd.

3 ***PLUG AND PLAY MULTI MEDIA HARDWARE, SOFTWARE COMPUTER SUPPORTED CO-OPERATIVE WORK SYSTEMS (CSCW)***

4 ***PLUG AND PLAY STRUCTURE, FACADE, HVAC, INTERIOR, CSCW, COGENERATION SYSTEMS***

Lifecycle and Integration of Building Systems



The Intelligent Workplace
as an enabling instrument for

Individual Comfort and Productivity
Organizational Flexibility
Technological Adaptability
Energy and Environmental Effectiveness

Center for Building Performance and Diagnostics, a NSF/IUCRC, and ABSIC at Carnegie Mellon

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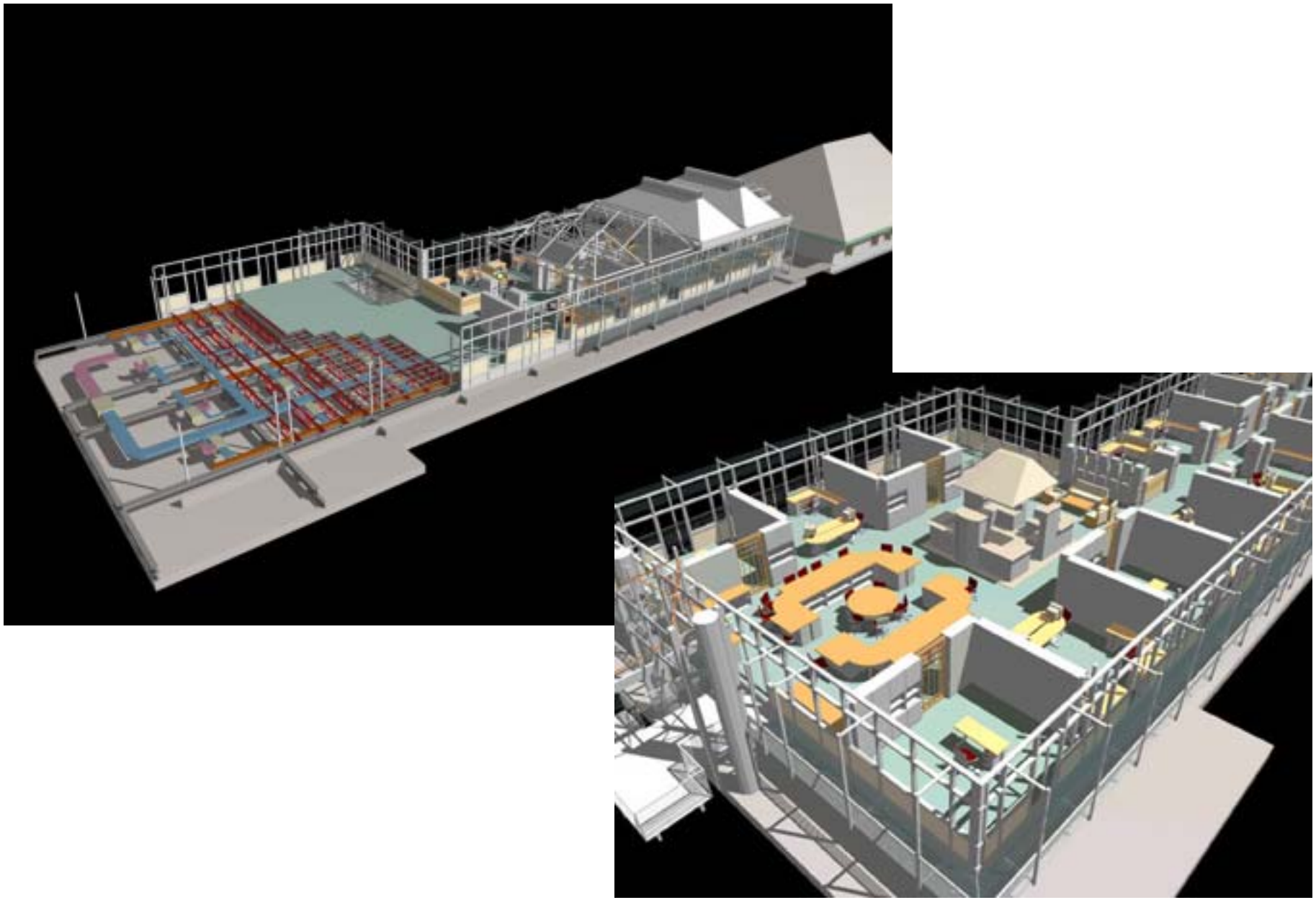
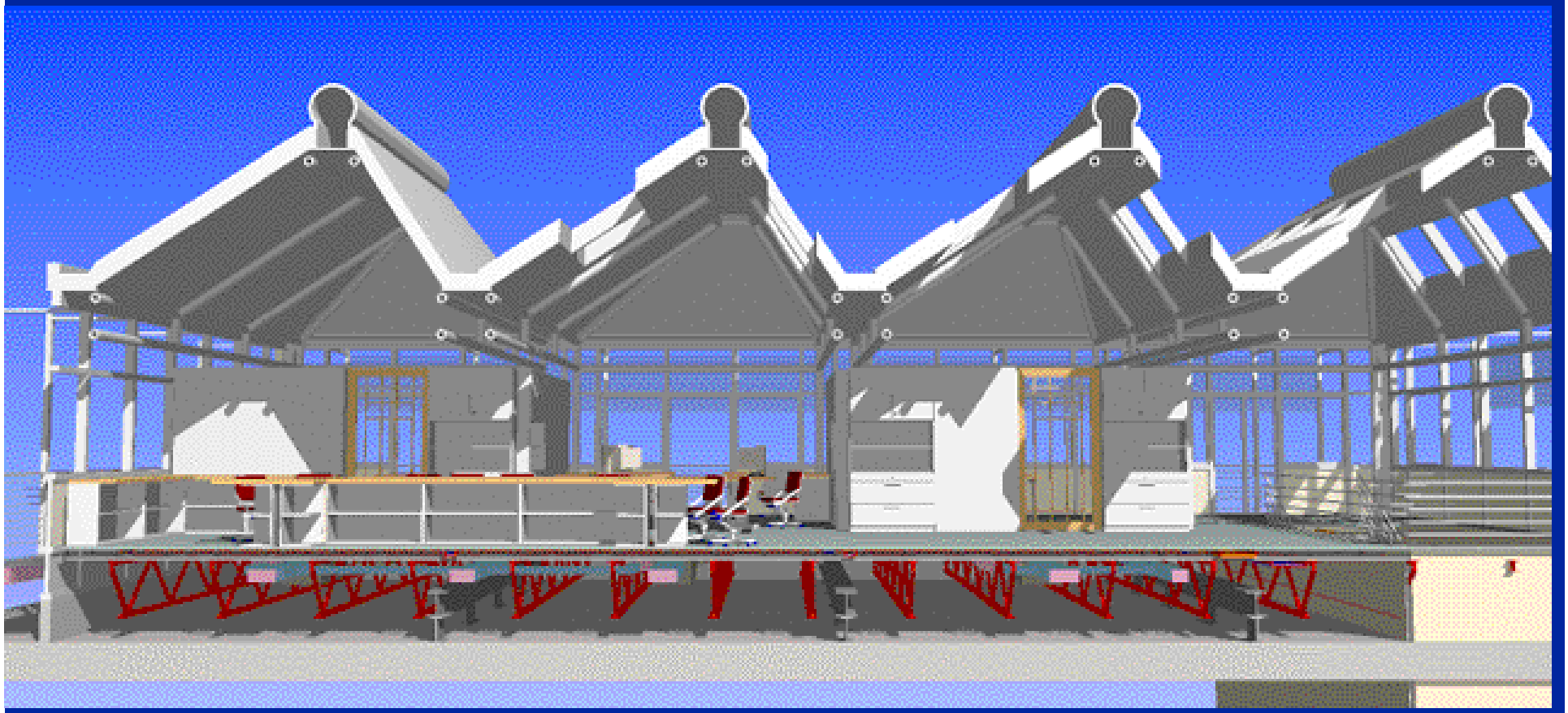
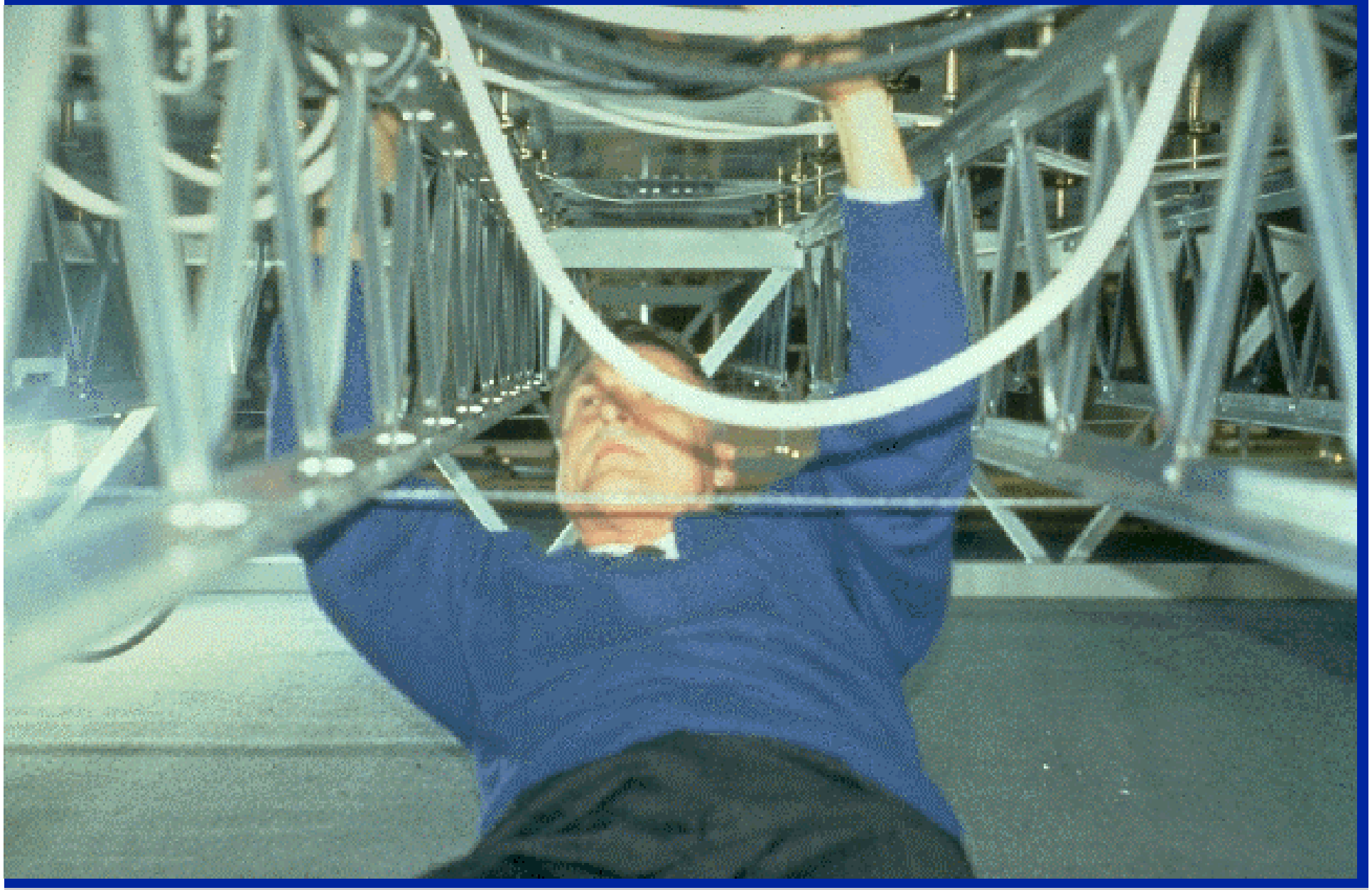
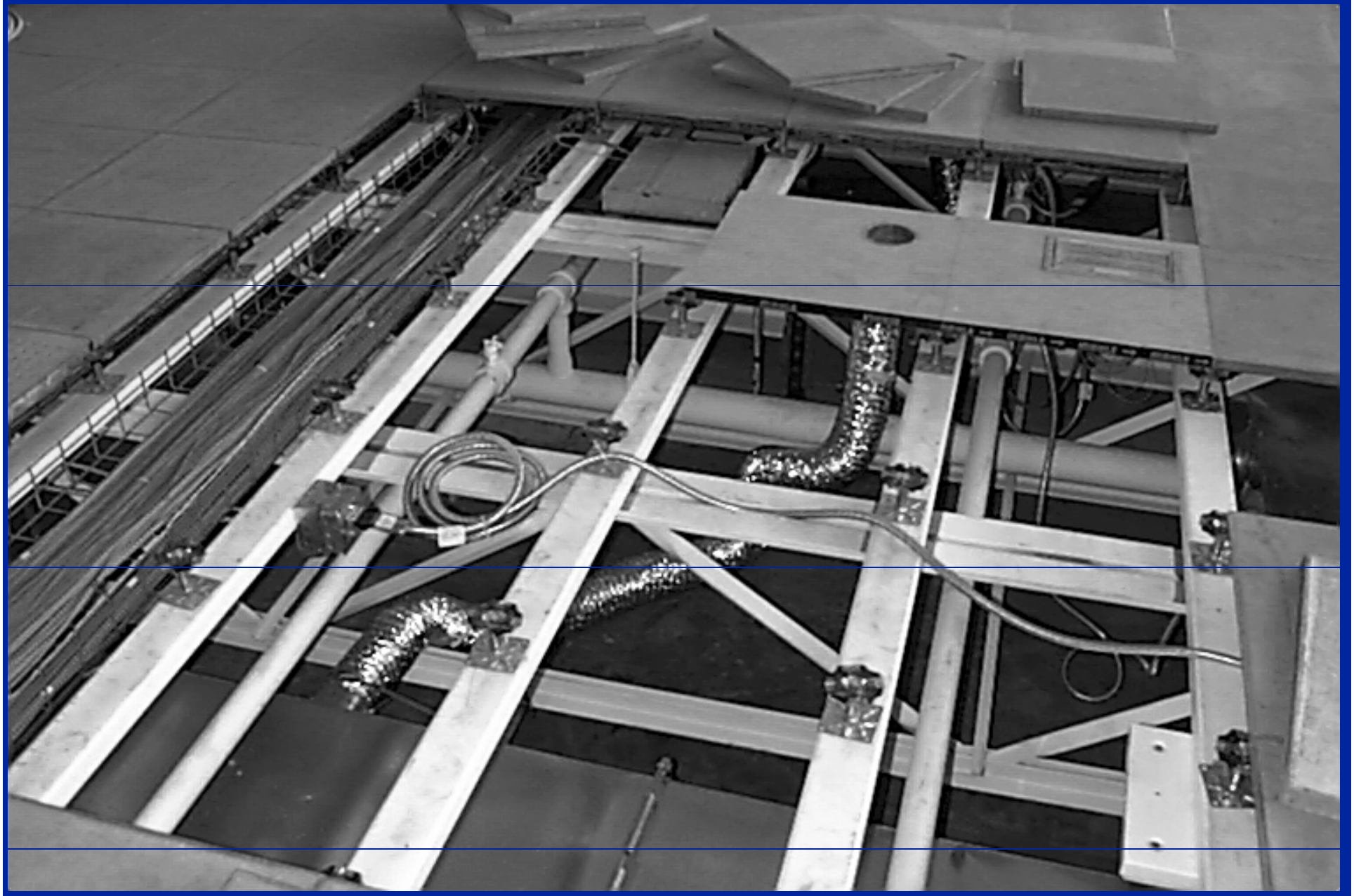






Center for Building Performance and Diagnostics, a NSF/IUCRC, and ABSIC at Carnegie Mellon



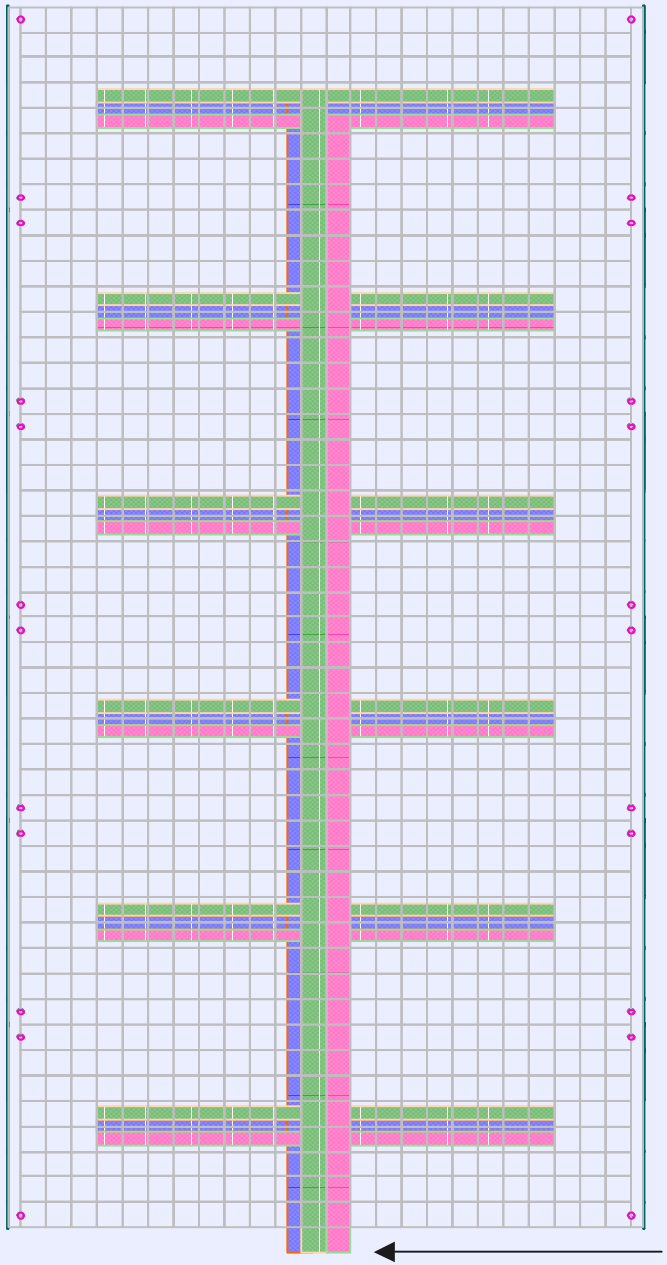
Center for Building Performance and Diagnostics, a NSF/IUCRC, and ABSIC at Carnegie Mellon

Courtesy: Johnson Controls

Johnson Controls Personal Environment Module [PEM™]

Courtesy: Johnson Controls

Johnson Control's Personal Environment Module [PEM™] supports user based outside air and temperature settings by introducing individual mixing boxes in the furniture. Users can set their own demands on the amount of conditioned outside air through ventilation speed and temperature control.



Underfloor Infrastructure distribution diagram

Center for Building Performance and Diagnostics, a NSF/IUCRC, and ABSIC at Carnegie Mellon

Center for Building Performance and Diagnostics, a NSF/IUCRC, and ABSIC at Carnegie Mellon

Applications

Kangnam Tower, Seoul, Korea

OC Headquarter, Toledo, Ohio

Soffer Organization Tech Offices, Pittsburgh,PA

Adaptable Workplace Laboratory,GSA, Wash.,DC

Region 3 Headquarter, DEP, Harrisburg, PA

Laboratory for the Design of Cognition, EDF, Paris

Beijing Energy Efficient Office Building, Beijing

Prizes

Regional: Three Rivers Environmental Prize, 1998

State: Green Building Prize, 1998

National: Honor Award, American Institute of Architects, 1999

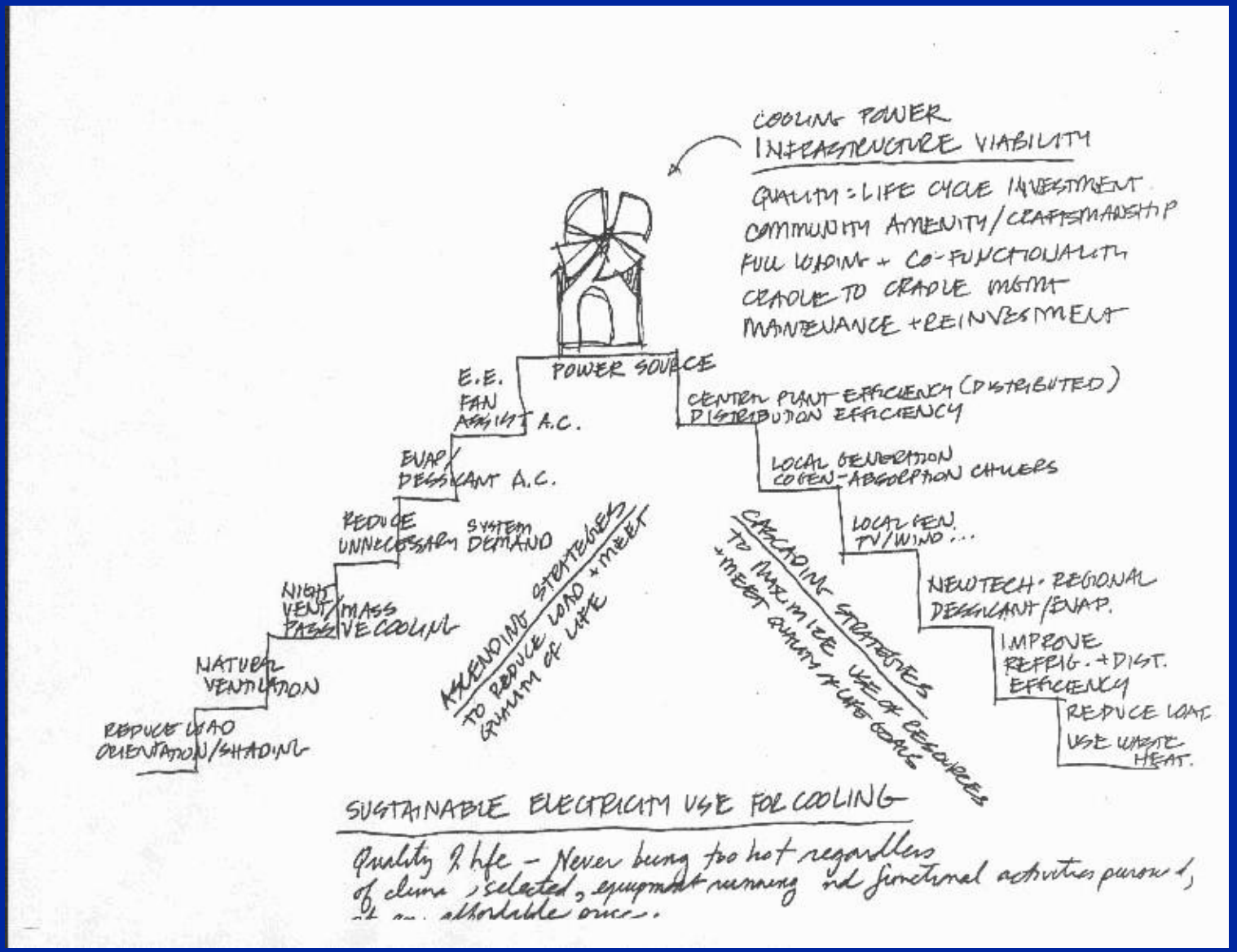
International: Business Week/Architectural Record Awards, 1999

Building as Power Plant (BAPP) - Intelligent Workplace Energy Systems

Project #5
Final Report: 2000-2001

Volker Hartkopf (PI), David Archer (Co-PI)
Azizan Aziz, Rohini Brahme
Colbi Cannon, Claudia Otto, Hongxi Yin

Center for Building Performance and Diagnostics, a NSF/IUCRC, and ABSIC at Carnegie Mellon

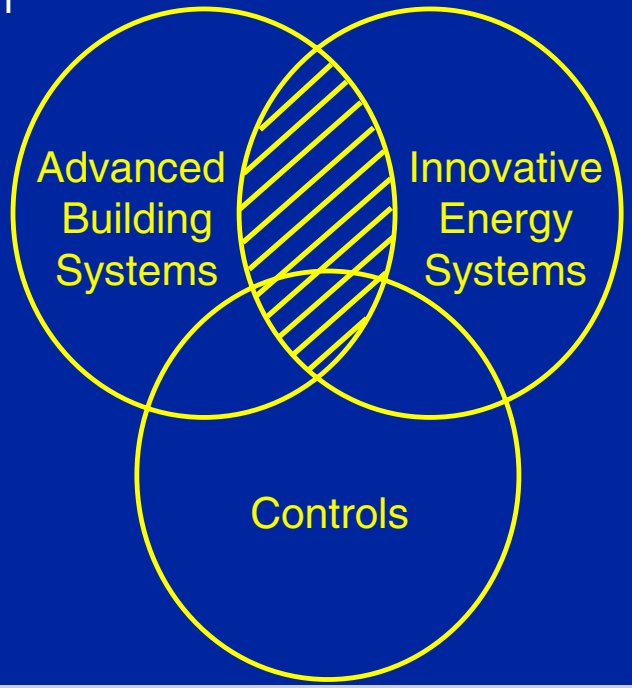

COOLING POWER
INFRASTRUCTURE VIABILITY
QUALITY = LIFE CYCLE INVESTMENT
COMMUNITY AMENITY / CRAFTSMANSHIP
FULL LOADING + CO-FUNCTIONALITY
CRADLE TO CRADLE MGMT
MAINTENANCE + REINVESTMENT
POWER SOURCE
CENTER PLANT EFFICIENCY (DISTRIBUTED)
DISTRIBUTION EFFICIENCY
LOCAL GENERATION
COGEN - ABSORPTION CHILLERS
LOCAL REN.
PV/WIND ...
NEW TECH - REGIONAL
DESSICANT/EVAP.
IMPROVE
REFRIG. + DIST.
EFFICIENCY
REDUCE LOAD
USE WASTE
HEAT
E.E.
FAN
ASSIST A.C.
EVAP/
DESSICANT A.C.
REDUCE
UNNECESSARY SYSTEM DEMAND
NIGHT
VENT/MASS
PASSIVE COOLING
NATURAL
VENTILATION
REDUCE LOAD
ORIENTATION/SHADING
ASCENDING STRATEGIES
TO REDUCE LOAD + MEET
QUALITY OF LIFE
CASCADING STRATEGIES
TO MAXIMIZE USE OF RESOURCES
+ MEET QUALITY OF LIFE GOALS
SUSTAINABLE ELECTRICITY USE FOR COOLING
Quality of life - Never being too hot regardless
of climate, selected, equipment running and functional activities pursued,
at an affordable price.

Concept

Buildings Can be Net Exporters of Energy

Systems Integration for:

- First, life cycle, environmental cost reduction
- Increased energy effectiveness
- Improved performance for user comfort
- Reliable and effective control technology
- Reliable energy supply
- Increased Return on Investment



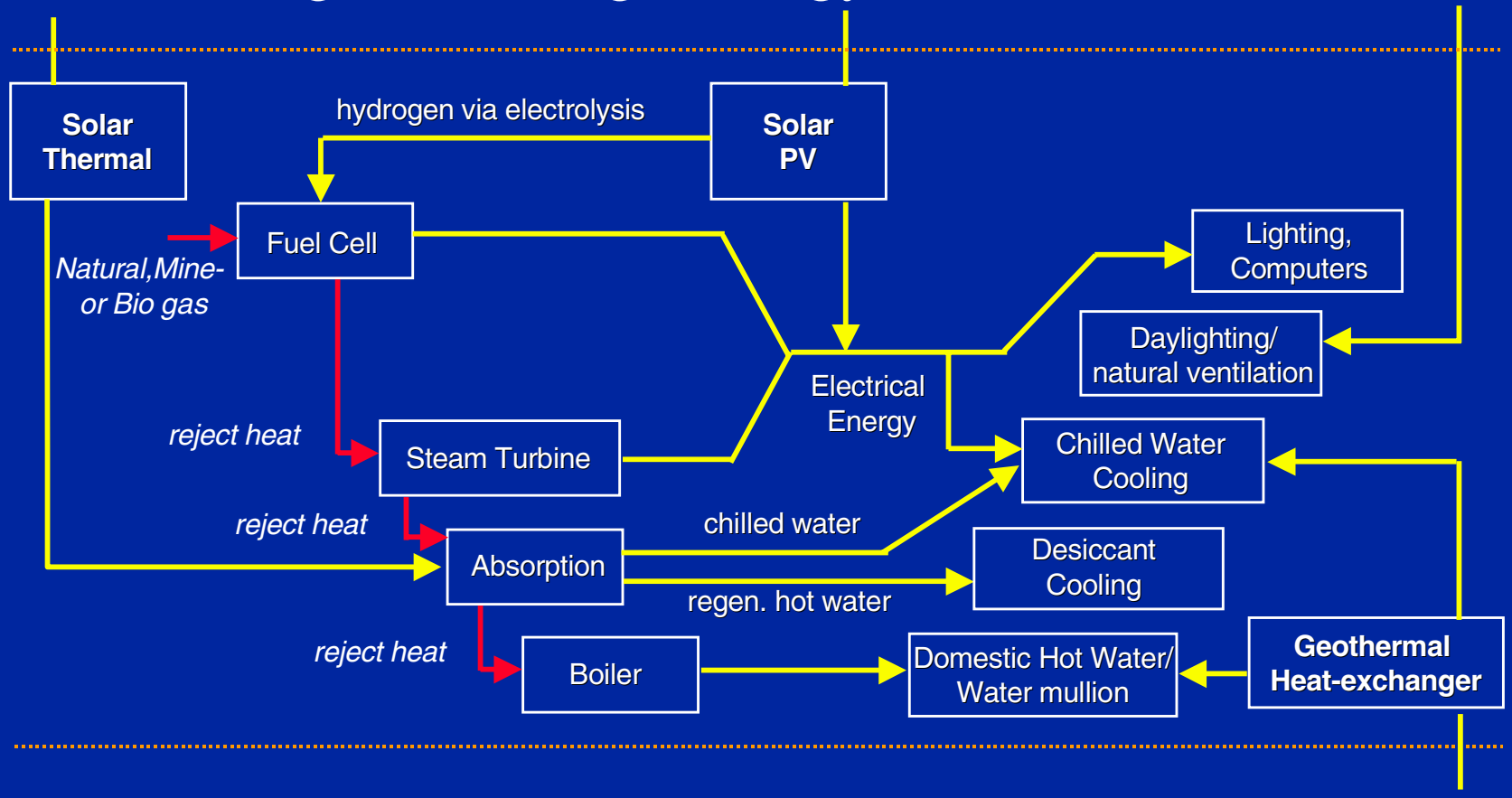
Advanced Building Systems

- Daylight
- Natural Ventilation
- Passive Solar Heating and Cooling
- Multi-mode Thermal Conditioning including Active Solar Systems
- User-based Controls and Conditioning

Innovative Energy Systems

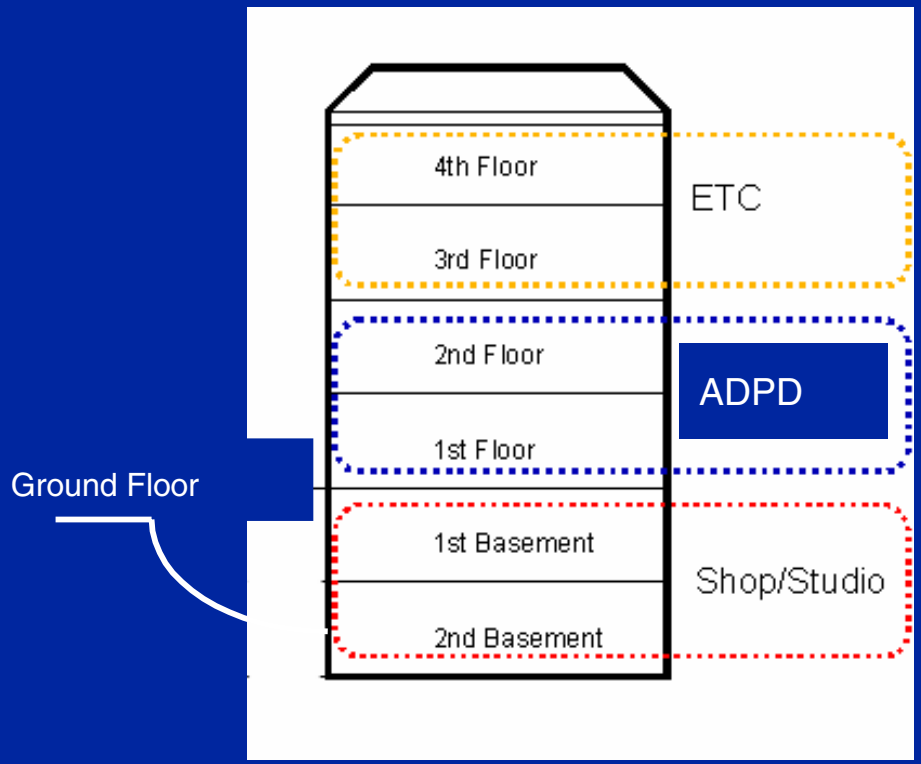
Multi-modal Conditioning

Descending-Ascending Strategy



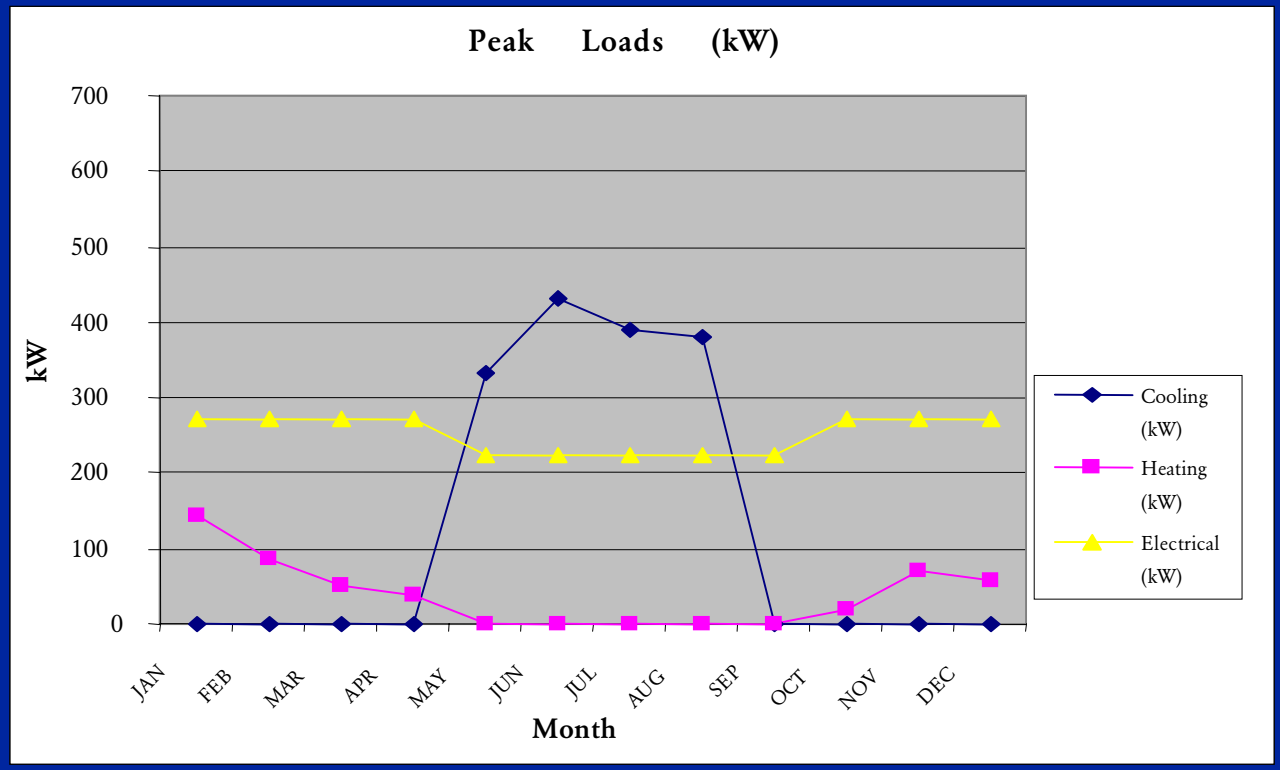
Expected Energy Demand of BAPP

Internal Energy of Each Space



	Equip. Loads	Lighting Loads
ETC	6 w/ft^2	1.3 w/ft^2
ADPD	2 w/ft^2	1.3 w/ft^2
Shop/Studio	7 w/ft^2	1.2 w/ft^2

Simulation Results

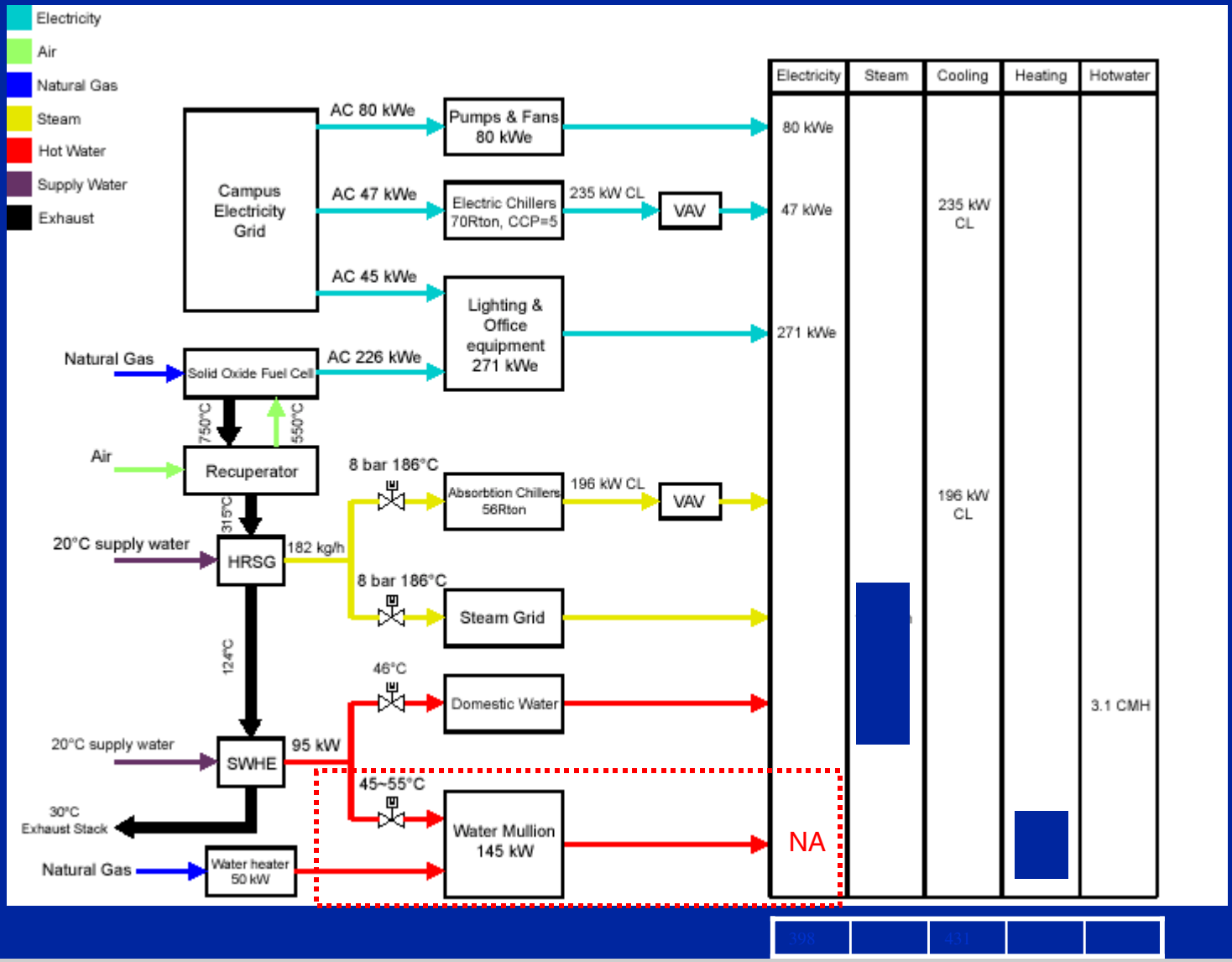


Note: Data taken from Dr. Rohini Brahme

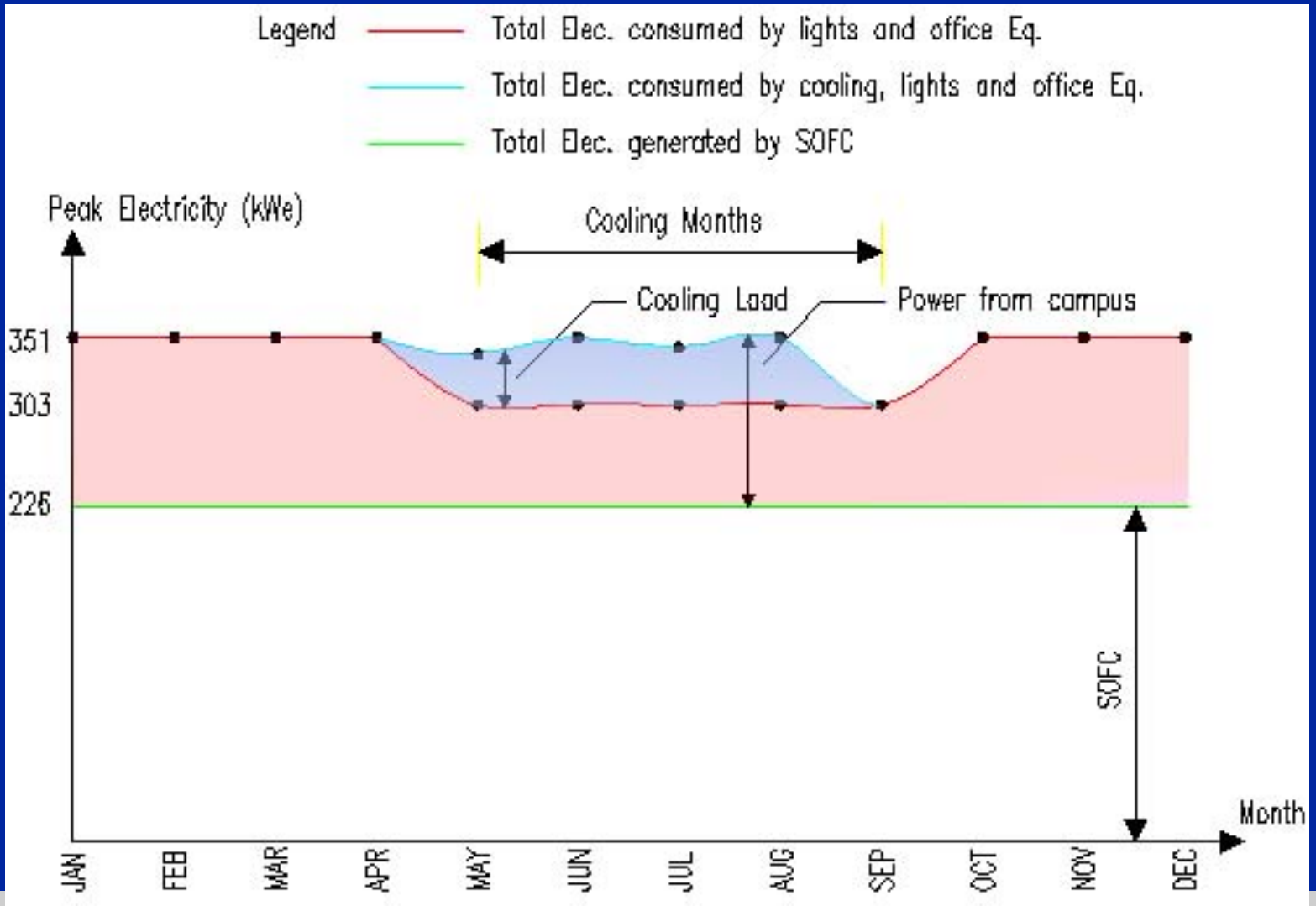
Scenario 1 - Configuration

- Solid oxide fuel cell
- Heat recovery steam generator
- Steam-water exchanger
- Absorption chiller
- Electrical chiller
- Water heater

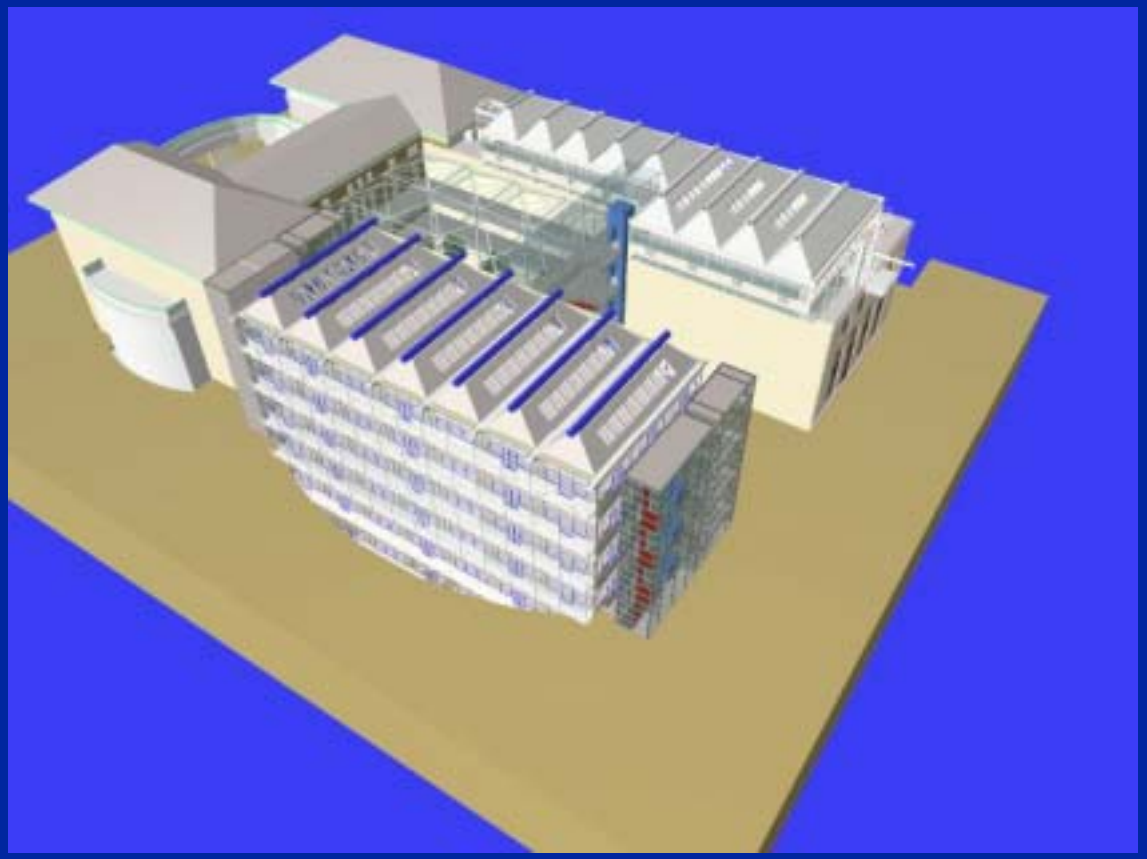
Scenario 1 – Summer

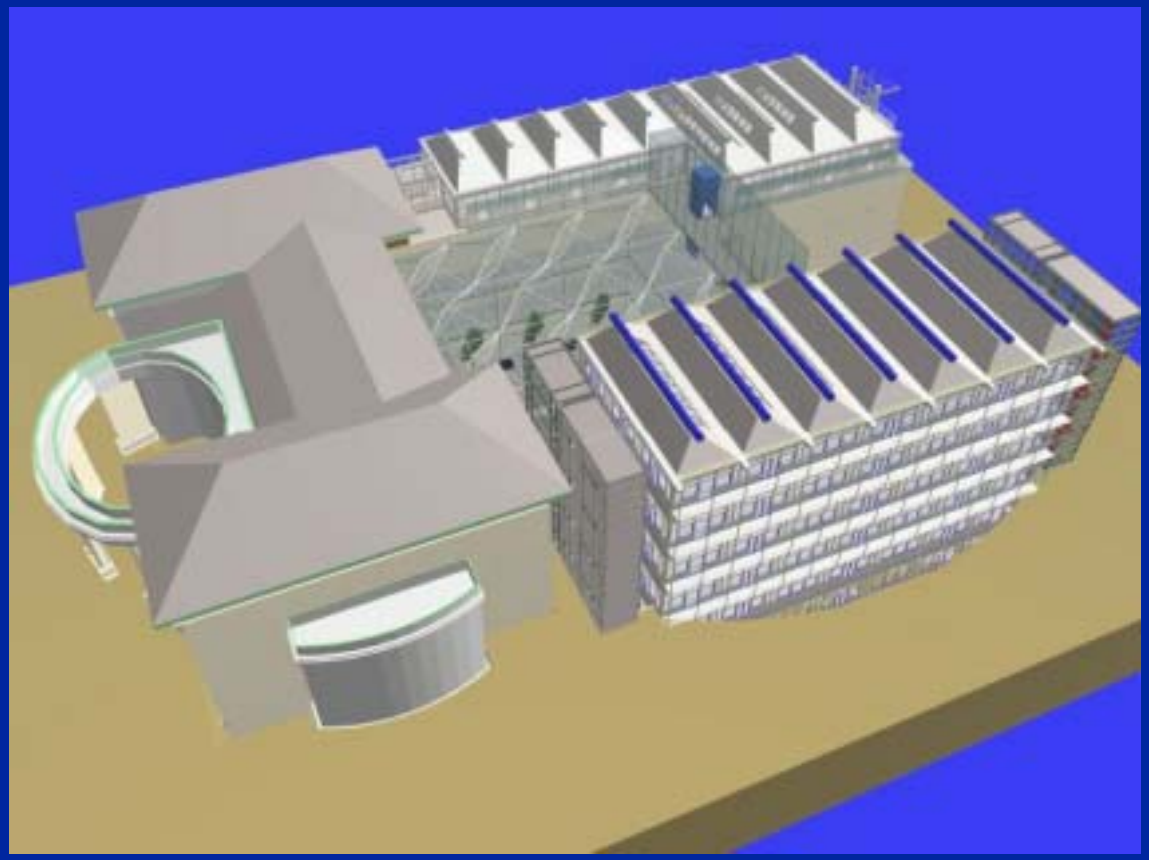


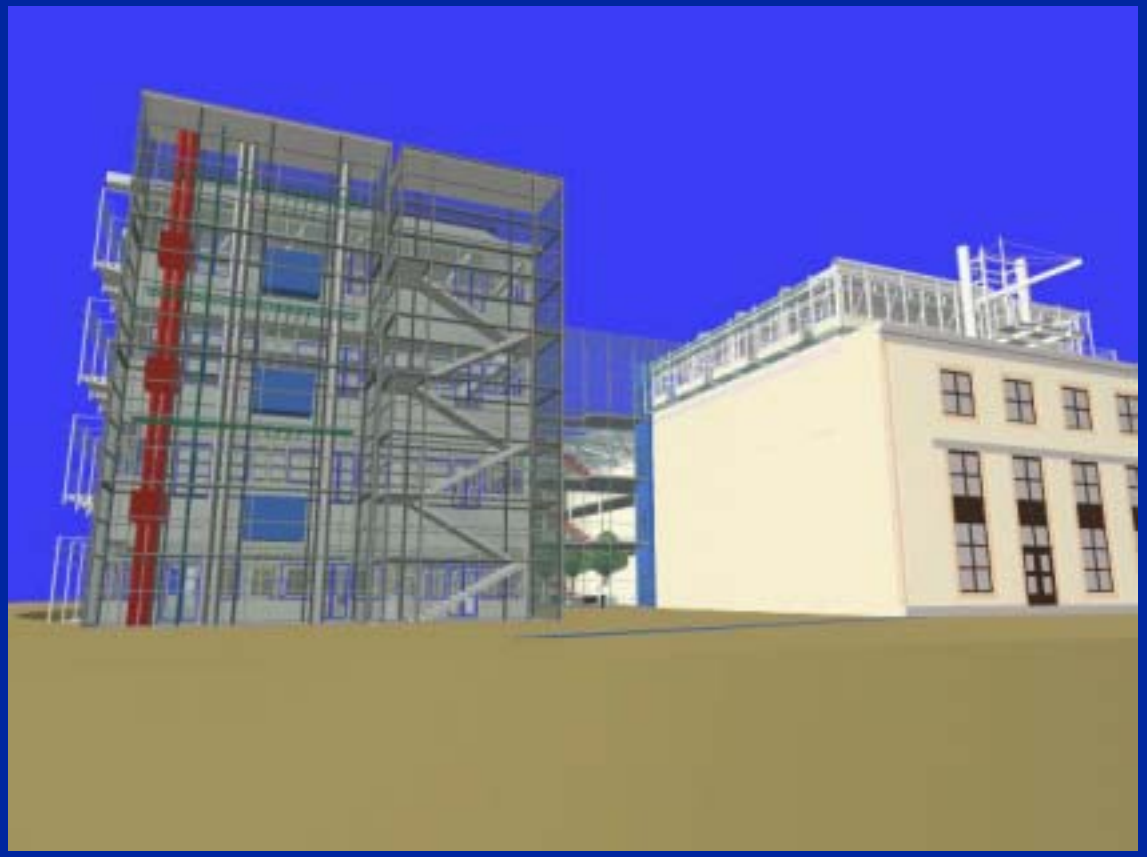
Scenario 1 – Electricity Curve

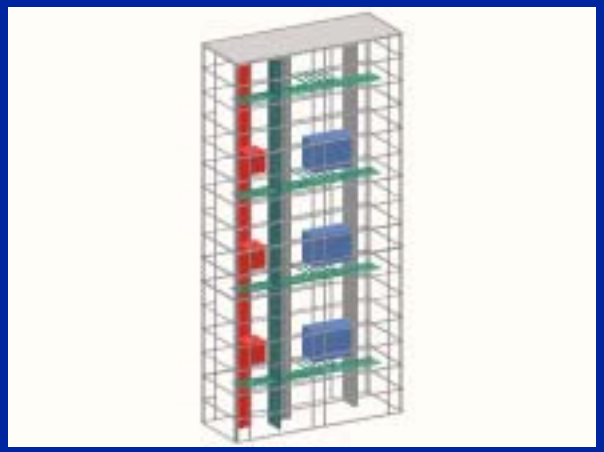


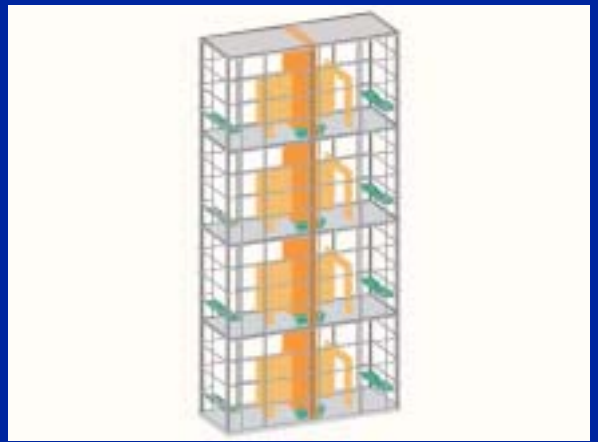
Preliminary Architectural Design

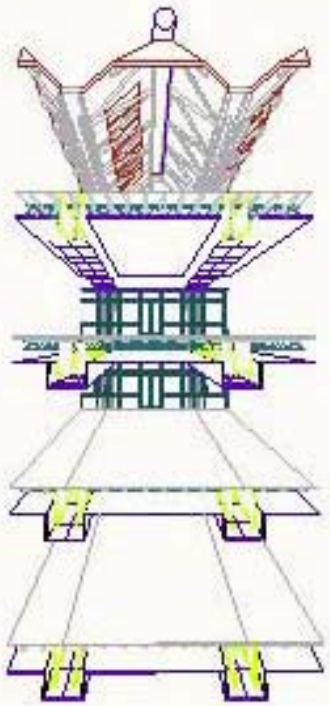













G45


GAS

The Vision

- Creating enabling environments
  - Data, Information, knowledge, wisdom
  - Learning, teaching, practicing
- Confluence of advanced electronic tools with the total environment
- Strategic advantage - effective conservation of key resources
  - Human attention & creativity
  - Organizational responsiveness
  - Nonrenewable Resources

hartkopf@cmu.edu